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(54) DATA STREAM QUALITY MANAGEMENT FOR ANALYTIC ENVIRONMENTS

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G06F 17/30 (2006.01)

(52) **U.S. Cl.**
CPC ... ***G06F 17/30312*** (2013.01); ***G06F 17/30516*** (2013.01)

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CPC G06F 17/30371; G06F 17/3028; G06F 17/30303; G06F 17/30312; G06F 17/30516
USPC 707/690, 754
See application file for complete search history.

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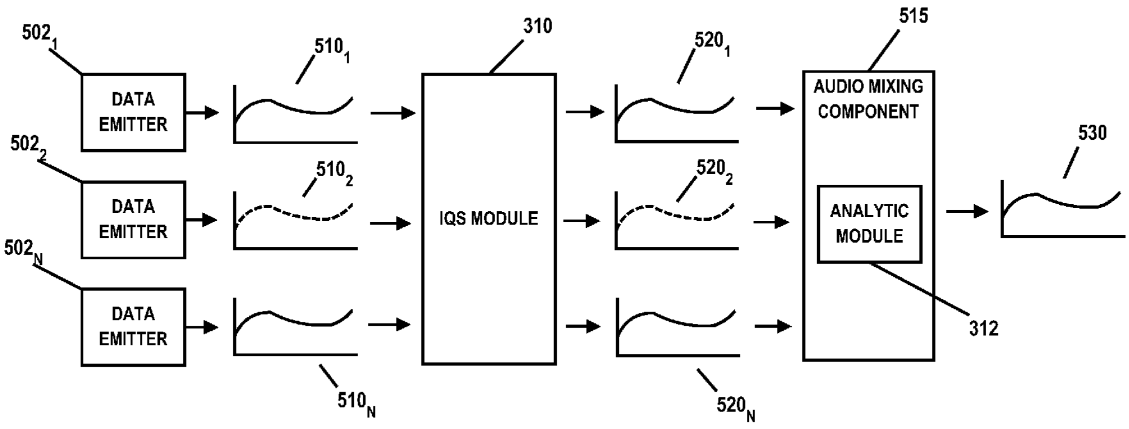
(57) **ABSTRACT**

According to one aspect of the present disclosure, a system and technique for data quality management is disclosed. The system includes a processor and an ingress quality specification (IQS) module executable by the processor in a runtime environment with a data stream analytic module. The IQS module is configured to: receive the data stream; analyze a subset of data of the data stream to determine if the subset of data meets a quality expectation of the analytic module; annotate the subset of data to indicate a quality status based on whether the subset of data meets the quality expectation of the analytic module; and output the data stream to the analytic module.

7 Claims, 4 Drawing Sheets



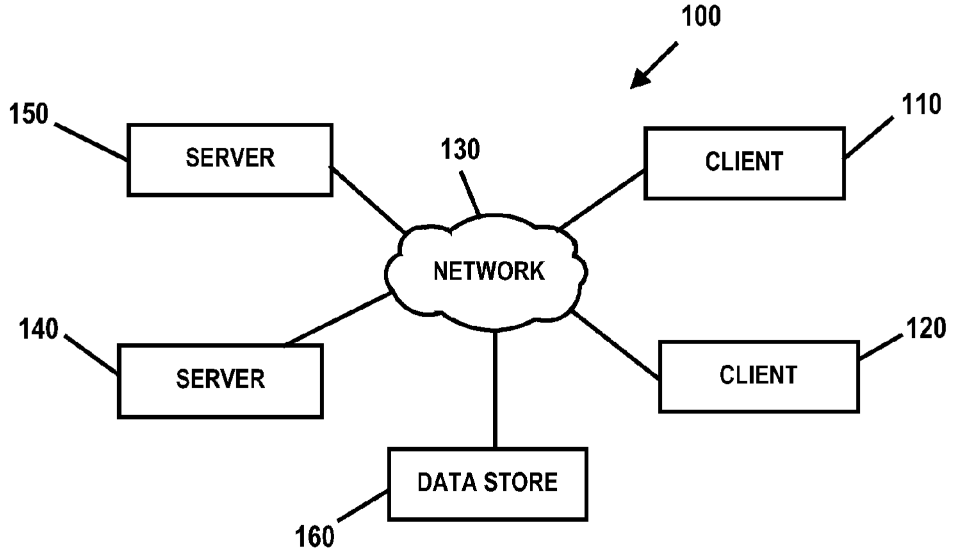

100
150
SERVER
130
CLIENT
110
NETWORK
140
SERVER
120
CLIENT
DATA STORE
160

FIG. 1

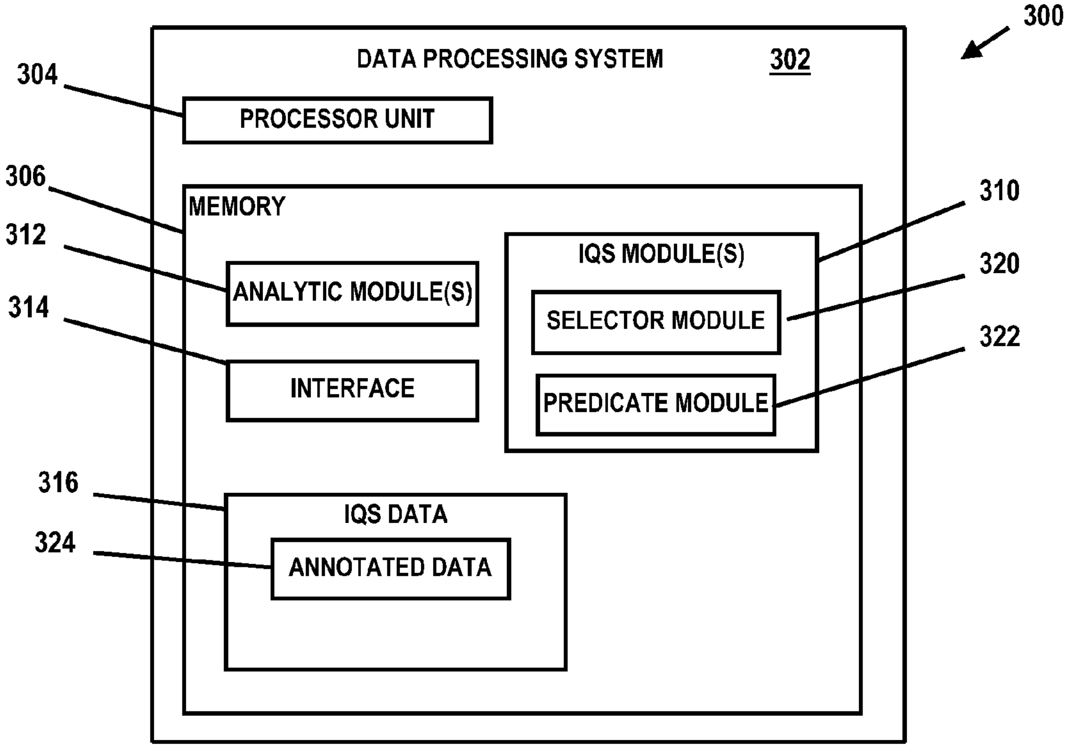

300
DATA PROCESSING SYSTEM
302
304
PROCESSOR UNIT
306
MEMORY
312
ANALYTIC MODULE(S)
314
INTERFACE
IQS MODULE(S)
310
SELECTOR MODULE
320
PREDICATE MODULE
322
316
IQS DATA
324
ANNOTATED DATA

FIG. 3

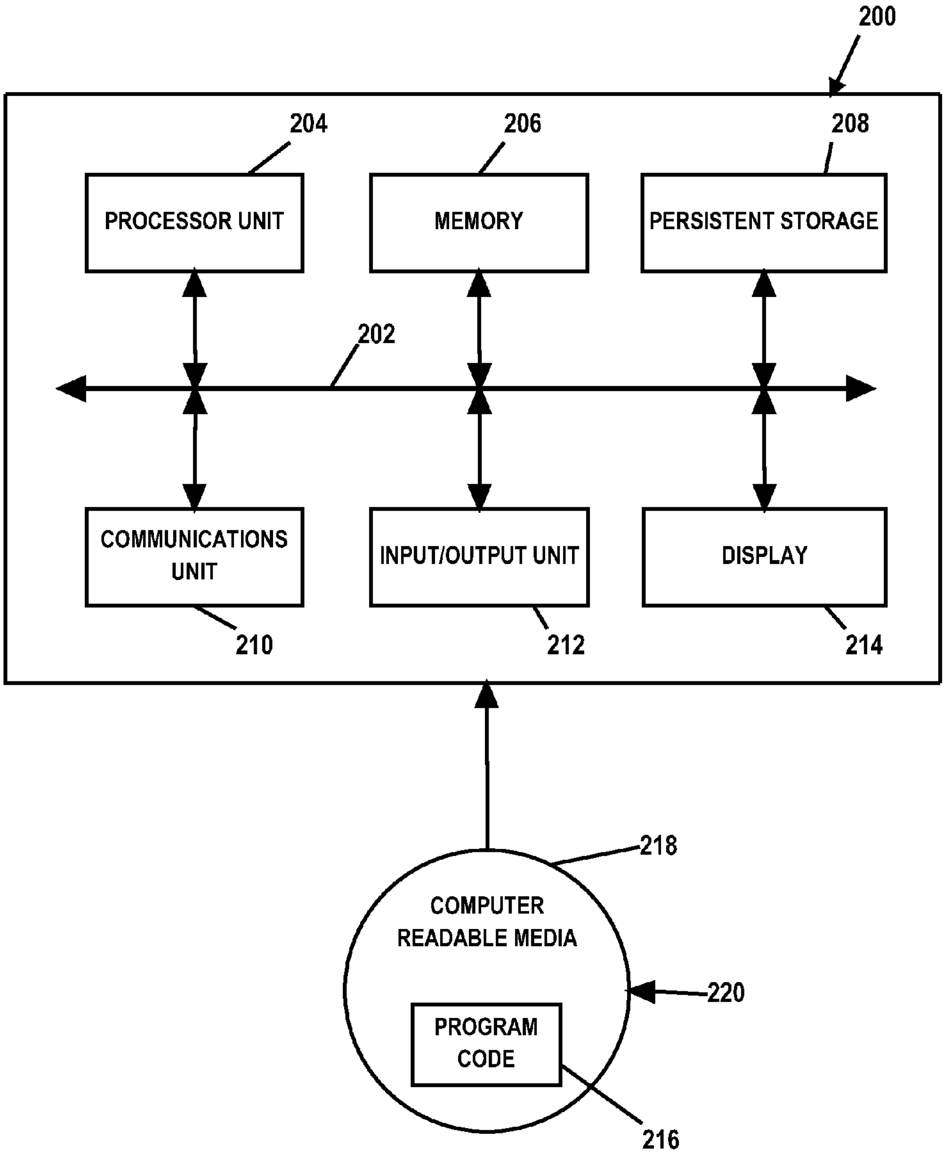

200
204
206
208
PROCESSOR UNIT
MEMORY
PERSISTENT STORAGE
202
COMMUNICATIONS UNIT
INPUT/OUTPUT UNIT
DISPLAY
210
212
214
218
COMPUTER READABLE MEDIA
220
PROGRAM CODE
216

FIG. 2

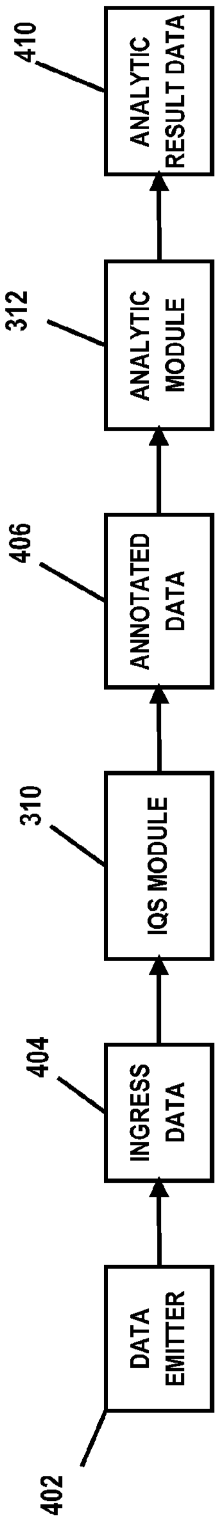

402
DATA EMITTER
404
INGRESS DATA
310
IQS MODULE
406
ANNOTATED DATA
312
ANALYTIC MODULE
410
ANALYTIC RESULT DATA

FIG. 4

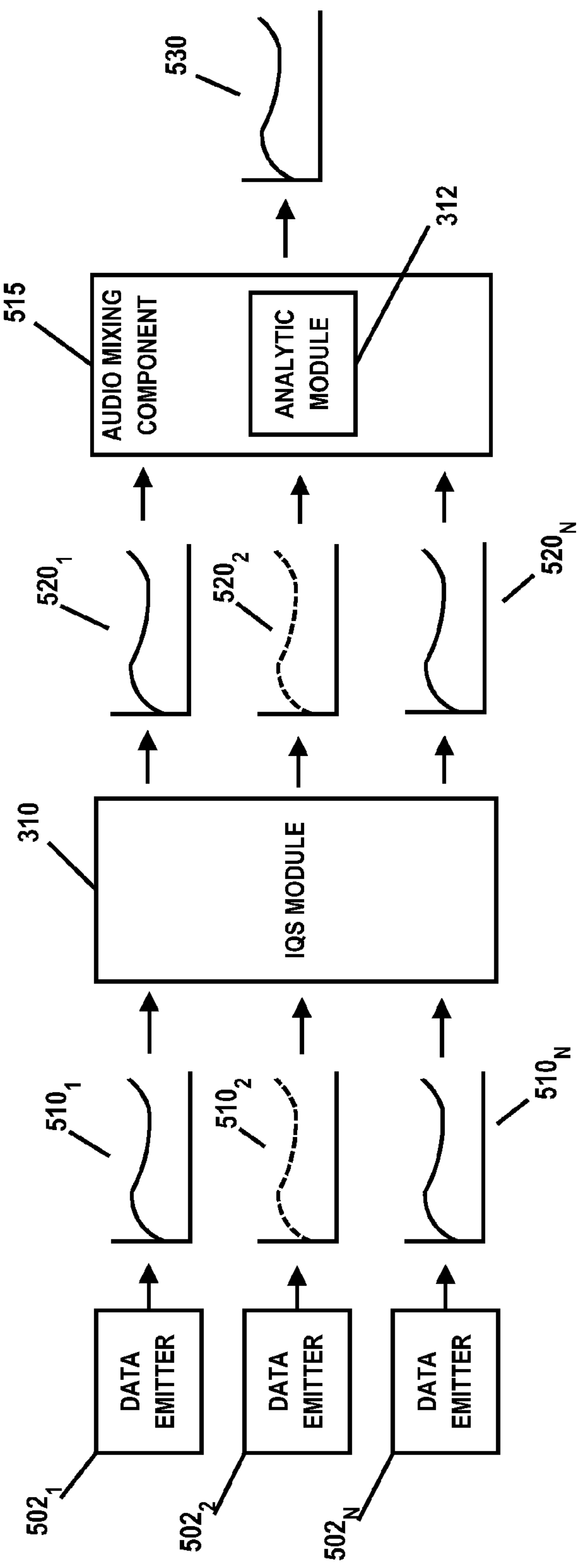

502_1
DATA EMITTER
502_2
DATA EMITTER
502_N
DATA EMITTER
510_1
510_2
510_N
310
IQS MODULE
520_1
520_2
520_N
515
AUDIO MIXING COMPONENT
ANALYTIC MODULE
312
530

FIG. 5

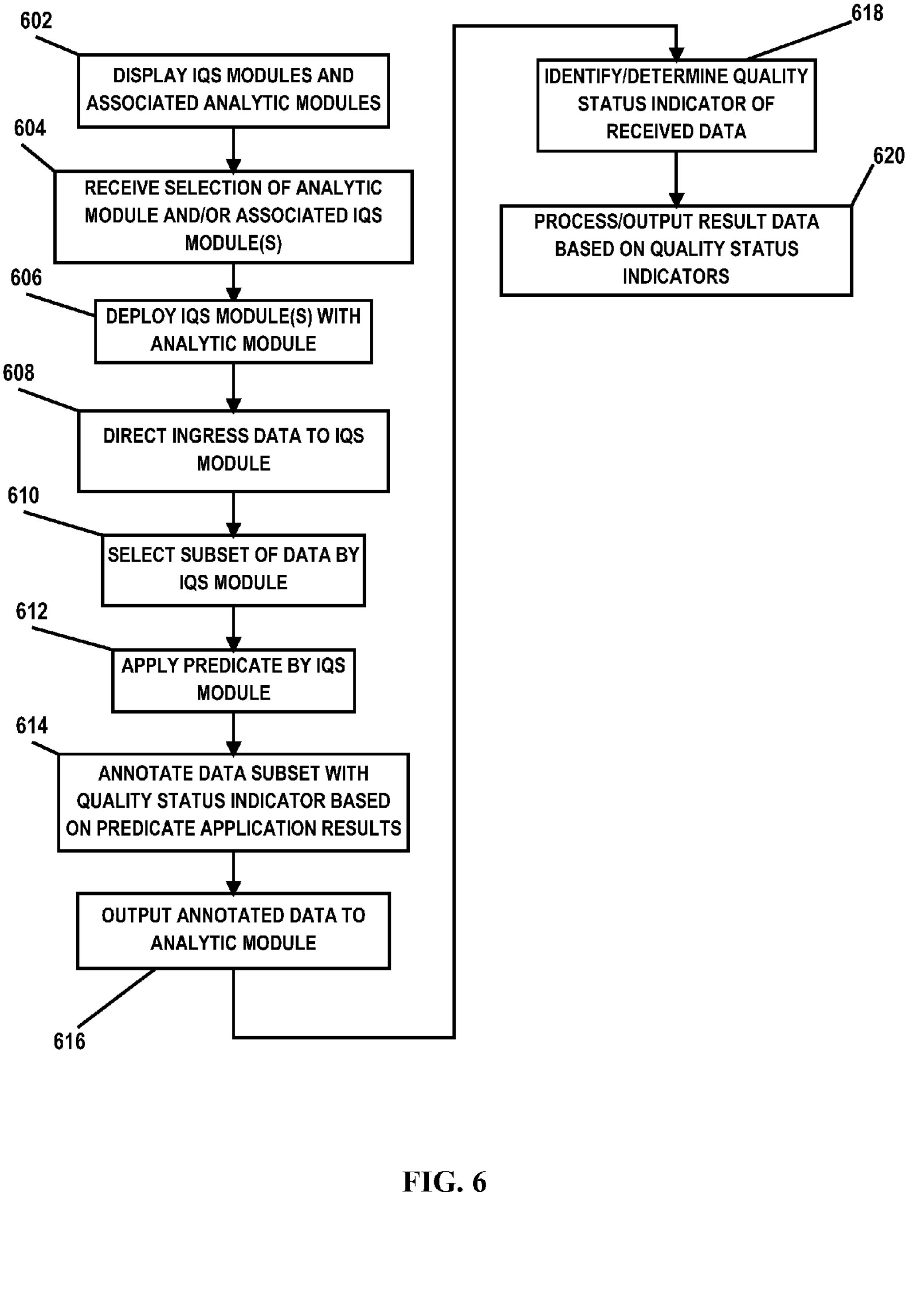

602
DISPLAY IQS MODULES AND ASSOCIATED ANALYTIC MODULES
604
RECEIVE SELECTION OF ANALYTIC MODULE AND/OR ASSOCIATED IQS MODULE(S)
606
DEPLOY IQS MODULE(S) WITH ANALYTIC MODULE
608
DIRECT INGRESS DATA TO IQS MODULE
610
SELECT SUBSET OF DATA BY IQS MODULE
612
APPLY PREDICATE BY IQS MODULE
614
ANNOTATE DATA SUBSET WITH QUALITY STATUS INDICATOR BASED ON PREDICATE APPLICATION RESULTS
OUTPUT ANNOTATED DATA TO ANALYTIC MODULE
616
618
IDENTIFY/DETERMINE QUALITY STATUS INDICATOR OF RECEIVED DATA
620
PROCESS/OUTPUT RESULT DATA BASED ON QUALITY STATUS INDICATORS

FIG. 6

DATA STREAM QUALITY MANAGEMENT FOR ANALYTIC ENVIRONMENTS

BACKGROUND

In various types of runtime environments, various types of data associated with usage (e.g., data traffic), environmental conditions (e.g., temperature), or other types of data may be collected via sensors or other types of devices and analyzed. This data is oftentimes analyzed in real time or as the data stream is being generated/communicated.

BRIEF SUMMARY

According to one aspect of the present disclosure a system and technique for data stream quality management in an analytic environment is disclosed. The system includes: a processor and an ingress quality specification (IQS) module executable by the processor in a runtime environment with a data stream analytic module. The IQS module is configured to receive the data stream; analyze a subset of data of the data stream to determine if the subset of data meets a quality expectation of the analytic module; annotate the subset of data to indicate a quality status based on whether the subset of data meets the quality expectation of the analytic module; and output the data stream to the analytic module.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a more complete understanding of the present application, the objects and advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. **1** is an embodiment of a network of data processing systems in which the illustrative embodiments of the present disclosure may be implemented;

FIG. **2** is an embodiment of a data processing system in which the illustrative embodiments of the present disclosure may be implemented;

FIG. **3** is a diagram illustrating an embodiment of a data quality management system for an analytic environment in which illustrative embodiments of the present disclosure may be implemented;

FIG. **4** is a diagram illustrating an embodiment of data flow processing according to the present disclosure;

FIG. **5** is a diagram illustrating another embodiment of data flow processing according to the present disclosure; and

FIG. **6** is a flow diagram illustrating an embodiment of a method for data quality management in an analytic environment according to the present disclosure.

DETAILED DESCRIPTION

Embodiments of the present disclosure provide a method, system and computer program product for data stream quality management in an analytic environment. For example, in some embodiments, the method and technique includes: deploying, into a runtime environment with a data stream analytic module, an ingress quality specification (IQS) module associated with the analytic module; receiving, by the IQS module, the data stream; analyzing, by the IQS module, a subset of data of the data stream to determine if the subset of data meets a quality expectation of the analytic module; annotating the subset of data to indicate a quality status based on whether the subset of data meets the quality expectation of the analytic module; and outputting the data stream to the analytic module. Thus, in some embodiments of the present disclosure, analytic modules and IQS modules may be developed and deployed independently of a runtime infrastructure in a plug-and-play manner. Embodiments of the present disclosure utilize the IQS module to pre-screen the ingress data to assess its quality level/characteristics based on a level of quality expected by the associated analytic module. Thus, embodiments of the present disclosure enable different IQS modules to be selected and deployed with one or more different analytic modules based on different quality and/or analysis contexts.

As will be appreciated by one skilled in the art, aspects of the present disclosure may be embodied as a system, method or computer program product. Accordingly, aspects of the present disclosure may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, aspects of the present disclosure may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

Any combination of one or more computer usable or computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus or device.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

Program code embodied on a computer readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

Aspects of the present disclosure are described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

With reference now to the Figures and in particular with reference to FIGS. **1**-**2**, exemplary diagrams of data processing environments are provided in which illustrative embodiments of the present disclosure may be implemented. It should be appreciated that FIGS. **1**-**2** are only exemplary and are not intended to assert or imply any limitation with regard to the environments in which different embodiments may be implemented. Many modifications to the depicted environments may be made.

FIG. **1** is a pictorial representation of a network of data processing systems in which illustrative embodiments of the present disclosure may be implemented. Network data processing system **100** is a network of computers in which the illustrative embodiments of the present disclosure may be implemented. Network data processing system **100** contains network **130**, which is the medium used to provide communications links between various devices and computers connected together within network data processing system **100**. Network **130** may include connections, such as wire, wireless communication links, or fiber optic cables.

In some embodiments, server **140** and server **150** connect to network **130** along with data store **160**. Server **140** and server **150** may be, for example, IBM® Power Systems™ servers. In addition, clients **110** and **120** connect to network **130**. Clients **110** and **120** may be, for example, personal computers or network computers. In the depicted example, server **140** provides data and/or services such as, but not limited to, data files, operating system images, and applications to clients **110** and **120**. Network data processing system **100** may include additional servers, clients, and other devices.

In the depicted example, network data processing system **100** is the Internet with network **130** representing a worldwide collection of networks and gateways that use the Transmission Control Protocol/Internet Protocol (TCP/IP) suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, consisting of thousands of commercial, governmental, educational and other computer systems that route data and messages. Of course, network data processing system **100** also may be implemented as a number of different types of networks, such as for example, an intranet, a local area network (LAN), or a wide area network (WAN). FIG. **1** is intended as an example, and not as an architectural limitation for the different illustrative embodiments.

FIG. **2** is an embodiment of a data processing system **200** such as, but not limited to, client **110** and/or server **140** in which an embodiment of a data quality management system according to the present disclosure may be implemented. In this embodiment, data processing system **200** includes a bus or communications fabric **202**, which provides communications between processor unit **204**, memory **206**, persistent storage **208**, communications unit **210**, input/output (I/O) unit **212**, and display **214**.

Processor unit **204** serves to execute instructions for software that may be loaded into memory **206**. Processor unit **204** may be a set of one or more processors or may be a multi-processor core, depending on the particular implementation. Further, processor unit **204** may be implemented using one or more heterogeneous processor systems in which a main processor is present with secondary processors on a single chip. As another illustrative example, processor unit **204** may be a symmetric multi-processor system containing multiple processors of the same type.

In some embodiments, memory **206** may be a random access memory or any other suitable volatile or non-volatile storage device. Persistent storage **208** may take various forms depending on the particular implementation. For example, persistent storage **208** may contain one or more components or devices. Persistent storage **208** may be a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above. The media used by persistent storage **208** also may be removable such as, but not limited to, a removable hard drive.

Communications unit **210** provides for communications with other data processing systems or devices. In these examples, communications unit **210** is a network interface card. Modems, cable modem and Ethernet cards are just a few of the currently available types of network interface adapters. Communications unit **210** may provide communications through the use of either or both physical and wireless communications links.

Input/output unit **212** enables input and output of data with other devices that may be connected to data processing system **200**. In some embodiments, input/output unit **212** may provide a connection for user input through a keyboard and mouse. Further, input/output unit **212** may send output to a printer. Display **214** provides a mechanism to display information to a user.

Instructions for the operating system and applications or programs are located on persistent storage **208**. These instructions may be loaded into memory **206** for execution by processor unit **204**. The processes of the different embodiments may be performed by processor unit **204** using computer implemented instructions, which may be located in a memory, such as memory **206**. These instructions are referred to as program code, computer usable program code, or computer readable program code that may be read and executed by a processor in processor unit **204**. The program code in the different embodiments may be embodied on different physical or tangible computer readable media, such as memory **206** or persistent storage **208**.

Program code **216** is located in a functional form on computer readable media **218** that is selectively removable and may be loaded onto or transferred to data processing system **200** for execution by processor unit **204**. Program code **216** and computer readable media **218** form computer program product **220** in these examples. In one example, computer readable media **218** may be in a tangible form, such as, for example, an optical or magnetic disc that is inserted or placed into a drive or other device that is part of persistent storage **208** for transfer onto a storage device, such as a hard drive that is part of persistent storage **208**. In a tangible form, computer readable media **218** also may take the form of a persistent storage, such as a hard drive, a thumb drive, or a flash memory that is connected to data processing system **200**. The tangible form of computer readable media **218** is also referred to as computer recordable storage media. In some instances, computer readable media **218** may not be removable.

Alternatively, program code **216** may be transferred to data processing system **200** from computer readable media **218** through a communications link to communications unit **210** and/or through a connection to input/output unit **212**. The communications link and/or the connection may be physical or wireless in the illustrative examples.

The different components illustrated for data processing system **200** are not meant to provide architectural limitations to the manner in which different embodiments may be implemented. The different illustrative embodiments may be implemented in a data processing system including components in addition to or in place of those illustrated for data processing system **200**. Other components shown in FIG. **2** can be varied from the illustrative examples shown. For example, a storage device in data processing system **200** is any hardware apparatus that may store data. Memory **206**, persistent storage **208**, and computer readable media **218** are examples of storage devices in a tangible form.

FIG. **3** is an illustrative embodiment of a system **300** for data quality management. System **300** may be implemented on data processing systems or platforms such as, but not limited to, servers **140** and/or **150**, clients **110** and/or **120**, or at other data processing system and/or node locations. For example, in the embodiment illustrated in FIG. **3**, system **300** comprises a data processing system **302** having a processor unit **304** and a memory **306**. In the embodiment illustrated in FIG. **3**, memory **306** includes one or more ingress quality specification (IQS) modules **310**, one or more analytic modules **312** an interface **314**, and IQS data **316**. IQS module(s) **310**, analytic modules(s) **312** and interface **314** may be implemented in any suitable manner using known techniques that may be hardware-based, software-based, or some combination of both. For example, IQS module(s) **310**, analytic modules(s) **312** and interface **314** may comprise software, logic and/or executable code for performing various functions as described herein (e.g., residing as software and/or an algorithm running on a processor unit, hardware logic residing in a processor or other type of logic chip, centralized in a single integrated circuit or distributed among different chips in a data processing system).

Analytic module(s) **312** is configured to analyze incoming data, such as an incoming data stream received from some type of object/data emitter (e.g., a sensor, gateway, router, etc.) to evaluate and/or otherwise provide an output of such analysis to enable various characteristics of the data stream, and thus the corresponding monitored object or data emitter, to be evaluated, monitored and/or analyzed. For example, analytic module **312** may be used to evaluate and/or analyze a data stream to determine whether the monitored object is performing as expected. Thus, in operation, the quality and reliability of the results produced by analytic module **312** is generally highly dependent on the quality of the incoming (ingress) data. Further, over time, various environmental effects (e.g., temporary lost connectivity to sensors, poor operational process, etc.) may cause the quality of ingress data to be compromised. The characteristics and use of particular analytic modules **312** may also be context-specific. For example, while one deployment of an instance of an analytic module **312** may have lower quality ingress data (e.g., a test facility having a relaxed expectation on the accuracy of the output of analytic module **312**), another environment (e.g., data used for service level agreement (SLA) enforcement) could have both expectations of high-quality ingress data as well as commensurate expectations on the results produced by that analytic module **312**.

IQS module(s) **310** is configured as a separate artifact from analytic module(s) **312** but is configured to take into consideration a quality characteristic of ingress data expected by a corresponding analytic module(s) **312**. For example, in some embodiments, IQS module(s) **310** is configured to pre-evaluate data that is targeted to a respective instance of an analytic module **312** to assess the quality of that data based on the quality of data expected by the respective instance of the analytic module **312** ordinarily needed to output useful and/or accurate results. In some embodiments, IQS module **310** includes a selector module **320** and a predicate module **322**. Selector module **320** is configured to select a subset of ingress data, and predicate module **322** is configured to apply a test or predicate to such data subset to determine whether such data subset meets a level of data quality expected by such analytic module **312**. The subset of ingress data selected by selector module **320** and the predicate applied by predicate module **322** corresponds to and/or is otherwise based on a data quality expectation of the associated analytic module **312**. For example, selector module **320** may be configured to select a particular subset of data targeted for the analytic module **312** against which a predicate is applied based on a rule applied to some set of the ingress data (e.g., a time period of collected data, a quantity of data points or count records, or other measure against which a predicate for data quality may be applied). Predicate module **322** applies a predicate against the selected data subset. The predicate applied by predicate module **322** may be used to determine whether the data subset contains spikes, gaps, missing data records, etc.

Interface **314** may comprise a graphical user interface (GUI) or other type of interface enabling a user and/or administrator to identify IQS modules **310** associated with particular analytic modules **312** and/or select particular IQS modules **310** for deployment with particular analytic modules **312**. For example, in some embodiments, IQS modules **310** and analytic modules **312** may be identified and/or otherwise associated with each other via a relational database, lookup table or otherwise. For example, a particular IQS module **310** may be configured to be deployed with one or more different analytic modules **312**. In this example, different IQS modules **310** may be configured to assess different data quality characteristics even though a data output from the different IQS modules **310** may be directed toward different instances of the same analytic module **312**. In some embodiments, interface **314** may be configured to enable the quality parameters of each IQS module **310** to be identified/determined by a user/administrator to enable the user/administrator to select and deploy particular IQS modules **310** based on the quality context sought for the associated analytic module **312**. Further, different IQS modules **310** (e.g., each configured to assess and/or determine a different quality characteristic for a corresponding data input) may be deployable with a particular analytic module **312**, thereby enabling different IQS modules **310** to be deployed for one particular analytic module **312**.

In operation, IQS module(s) **310** may be specified independently of, but with consideration of, the particular analytic module **312** the IQS module(s) **310** will be used with. In some embodiments, both the IQS modules(s) **310** and the target analytic module(s) **312** are configured as plug-and-play into a core infrastructure. For example, IQS module(s) **310** may be compiled into a form suitable for the target runtime environment or can be left in raw (text) form and have the compilation/binding occur at runtime (e.g., as is typical for dynamic language systems). The IQS module(s) **310** (or its derived form) is deployed and bound into the runtime infrastructure with the respective analytic module **312**. At runtime, data typically intended for or typically directly presented to a particular analytic module **312** is first routed to runtime artifacts created based upon processing of the IQS module(s) **310**. Subsets of that data, based upon the selector criteria applied by selector module **320**, are tested against a predicate by predicate module **322**. In some embodiments, the data analyzed by IQS module **310** is annotated with a result of the selection/predicate test. For example, in some embodiments, data which satisfies the applied predicate are flagged as having 'passed' the IQS predicate test, and data which does not satisfy the predicate are flagged as having 'failed' the IQS predicate test. The flagged and/or annotated data is output by IQS module **310** to the target analytic module **312** where analytic algorithm-specific behavior based on this pass/fail consideration can be made by analytic module **312**. In FIG. **3**, the annotated data is illustrated as annotated data **324**. Thus, for example, in some embodiments, analytic module **312** may be deployed independently of any IQS module **310**. A user/administrator can thereafter install and/or otherwise deploy an instance of an IQS module **310** and associate/link the particular IQS module **310** with the particular deployed analytic module **312**. Similarly, embodiments of the present invention may provide an IQS module **310** template from which various instances of the particular IQS modules **310** may be created and then be associated with particular instances of a corresponding analytic module **312**. The user/administrator may also set appropriate configurations on the IQS module **310** instances.

It should be understood that the annotation of data resulting from the application of the predicate test by IQS module **310** may vary. For example, as described above, both data passing and failing the predicate test may be annotated. However, in some embodiments, either only the data passing the IQS predicate test or only the data failing the predicate test may be correspondingly annotated. Annotations of the data output by IQS module **310** enables the analytic module **312** to discern between data passing or failing the predicate test applied by IQS module **310**. The annotating and/or flagging of the data based on a result of the IQS predicate application may vary. For example, in some embodiments, an additional field on a tuple may be used to indicate the quality status resulting from the IQS predicate test. However, it should be understood that other methods may be used to flag or annotate the quality status of the analyzed data.

In some embodiments, multiple IQS modules **310** may be deployed with a particular instance of an analytic module **312**. For example, in some embodiments, each different IQS module **310** may receive and process a data stream destined for the analytic module **312** and apply its respective IQS selector/predicate test to the data stream. Each IQS module **310** may annotate the output data correspondingly. For example, in some embodiments, a data stream may first be input to one IQS module **310**, annotated based on its IQS predicate test, the resulting annotated data output to another IQS module **310**, annotated based on its IQS predicate test, and the resulting annotated data input to analytic module **312**. The analytic module **312** may be configured to discern between different annotations in the data (e.g., based on particular field values or other flag information).

FIG. **4** is a diagram illustrating data processing according to the present disclosure. In the embodiment illustrated in FIG. **4**, a data emitter **402** (e.g., a sensor, router, or other type of device outputting data based on a monitored object or other type of data acquisition device) outputs data **404**. The data **404** may comprise a series of data points or records, a continuous (or substantially continuous) flow of data (e.g., a music signal, voltage level signal, etc.) or other type or form of output data (referred to herein as a data stream). The data **404** is input to IQS module **310**. Selector module **320** analyzes the input data **404** and selects a subset of the data against which to apply a predicate. Predicate module **322** applies the predicate to the selected subset of data and determines whether the subset of data meets the predicate (passes) or not (fails). IQS module **310** annotates the subset of data based on the result of the predicate application to indicate a quality status corresponding to the selected subset and thereafter outputs the annotated data **406** to analytic module **312**.

Analytic module **312** receives the annotated data **406** and analyzes the annotated data **406** based in its defined analysis algorithm. In some embodiments, analytic algorithm **312** analyzes the annotated data **406** to determine a quality status of the data. For example, in some embodiments, analytic module **312** identifies flags, field values, or other codes representing a quality status to determine which data met or passed the predicate applied by IQS module **310** and which data did not meet the applied IQS predicate. In some embodiments, analytic module **312** may omit data from analysis/output that did not meet the IQS predicate or was not indicated/flagged as having the requisite quality level/status. As an example, consider that data emitter **402** is configured to poll and/or output a data record every ten minutes. In this example, selector module **320** may select a window of received data corresponding to 3600 seconds (one hour). The IQS predicate for a selected window or subset of the received data may be that all six values for a corresponding period (3600 seconds) are needed by a corresponding analytic module **312** (e.g., to compute/output an hourly average). Thus, if a data record count is less than six for the selected window/subset of data, IQS module **310** may flag the data subset with a quality status identifier indicating that the data subset did not meet the quality predicate. The annotated/flagged data is then output by IQS module **310** to analytic module **312**. Analytic module **312** processes the received data and generates an output or analytic result data **410**. Analytic module **312** identifies the quality status indication and, in some embodiments, does not output a result for the corresponding time period in result data **410**. Thus, if the data received by analytic module **312** for a particular time period (or a particular subset of data) does not meet a quality level as defined by IQS module **310**, analytic module **312** may omit such data or omit an output of an analysis of such data. If a user/administrator desires to change a measurement and/or quality context (e.g., instead of one data record every ten minutes, a data record is output/received every one minute, and a minimum of forty-five data records for a 3600 second time period are needed to compute a reasonable average for such time period), a different IQS module **310** may be selected/deployed with the same analytic module **312** (e.g., replacing one IQS module **310** with a different IQS module **310**). The new IQS module **310** would include a corresponding predicate for analyzing and annotating a subset of data that includes at least forty-five data records for such 3600 second time period.

FIG. **5** is a diagram illustrating another embodiment of data processing according to the present disclosure. In this embodiment, IQS module **310** receives digital audio data from a plurality of different sources or data emitters **502**$_1$-**502**$_n$. In this example, each data emitter **502**$_1$-**502**$_n$ outputs or provides a respective digital audio signal **510**$_1$-**510**$_n$. In the embodiment illustrated in FIG. **5**, an audio mixing component **515** may be used to provide audio mixing of received digital audio data. Thus, in the illustrated embodiment, audio mixing component **515** may include analytic module **312** for identifying a data quality status indicator for received audio signals. Selector module **320** may select a subset of received digital audio data for each digital audio data stream corresponding to some defined window or time period. Predicate module **322** applies the quality predicate (e.g., some minimum quantity of data samples). In this example, IQS module **310** may identify signal **510**$_2$ from emitter **502**$_2$ as having low data quality or a level of data quality falling below the applied predicate. IQS module **310** annotates the audio signals output to analytic module **312** with a corresponding quality status indicator (output as annotated digital audio signals **520**$_1$-**520**$_n$). As described above, IQS module **310** may annotate each digital audio signal stream with a status indicator identifying such data as either having passed or failed the quality predicate applied by IQS module **310** (or IQS module **310** may only annotate the digital audio data streams that passed the predicate, or vice versa). In this example, analytic module **312** may be configured to omit a particular audio signal from such audio mixing if such signal is of low data quality. This, in this example, analytic module **312** identifies the quality status indicators in signals **520**$_1$-**520**$_n$ and, responsive to determining that signal **520**$_2$ contained a low data quality status indication, omit signal **510**$_2$/**520**$_2$ from an audio signal mix **530** output by mixing component **515**.

FIG. **6** is a flow diagram illustrating an embodiment of a method for data quality management. The method begins at block **602**, where interface **314** displays and/or otherwise presents information corresponding to analytic modules **312** and/or IQS modules **310**. For example, a user or administrator may view and/or otherwise identify particular analytic modules **312** to deploy or, if already deployed, identify particular IQS modules (including their associated quality predicate parameters). At block **604**, system **302** receives a selection of an analytic module **312** or, if already deployed, a selection of one or more IQS modules **310** that are associated with a designated analytic module **312**. For example, a user/administrator may use interface **314** to identify and/or otherwise select particular IQS modules **310** to deploy with a particular analytic module in a runtime environment (or to replace an already deployed IQS module **310**). At block **606**, the selected IQS module(s) **310** are deployed into the runtime environment and bound to a respective analytic module **312**. For example, binding the selected IQS module **310** to the analytic module **312** may be performed to configure system **302** to route ingress data typically destined to analytic module **312** to IQS module **310** instead. The IQS module **310** may also be configured to output its data to the respective analytic module **312**.

At block **608**, ingress data (e.g., from a data emitter, such as emitter **402** or **502**) is directed to IQS module **310**. At block **610**, selector module **320** selects and/or otherwise identifies a subset of the received data against which to apply an IQS predicate. At block **612**, predicate module **322** applies the IQS predicate and/or otherwise tests the subset of data against the IQS predicate. At block **614**, IQS module **310** annotates the subset of data with quality status indicators to indicate whether the subset of data met the applied IQS predicate. At block **618**, IQS module **310** outputs the annotated data to analytic module **312**. At block **618**, analytic module **312** identifies and/or otherwise determines the quality status corresponding to the received data (e.g., identifying flags, reading field values, and/or otherwise determining whether the received data is of a quality expected by analytic module as defined by the predicate applied by IQS module **310**). At block **62**, analytic module **312** processes and/or otherwise outputs a result based on the quality status indicators (e.g., omitting a result for a particular subset of data, omitting low quality data from an output result, etc.).

Thus, embodiments of the present disclosure enable analytic modules and IQS modules to be developed and deployed independently of a target infrastructure in a plug-and-play manner. For example, embodiments of the present disclosure enable a variety of different quality/data analysis assemblies (i.e., combinations of analytic modules and IQS modules) of domain/technology specific contexts to be selected and deployed in a runtime environment. Thus, embodiments of the present disclosure enable a particular quality specification to be used in different contexts. For example, embodiments of the present disclosure enable a single analytic module to be associated with multiple IQS module instances, thereby enabling multiple quality requirements to be applied to a particular analytic module in a conjunctive manner. Embodiments of the present disclosure also provide potential computation savings (e.g., by avoiding expensive analytic module computation using low-quality data).

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The embodiment was chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function (s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

What is claimed is:

1. A system, comprising:

an analytic module configured to analyze a data stream output by an object and output an analysis of the object, the analytic module having a data quality expectation of data of the data stream;

a memory storing a plurality of ingress quality specification (IQS) modules each corresponding to a different quality characteristic and each associated with the analytic module; and

an interface configured to enable a selection of at least one IQS module from the plurality of IQS modules to deploy with the analytic module to:

receive the data stream from the object;

analyze a subset of data of the data stream to determine if the subset of data meets the quality expectation of the analytic module;

modify the subset of data by annotating the subset of data to indicate a quality status based on whether the subset of data meets the quality expectation of the analytic module; and

output the data stream to the analytic module; and

wherein the analytic module is configured to receive the data stream from the IQS module, identify data not meeting the quality expectation based on the annotations, and omit from its analysis of the object the data not meeting the quality expectation; and

wherein the selected IQS module is configured to determine whether a selected subset of data of the data stream includes a minimum quantity of data samples based on the quality expectation of the analytic module.

2. The system of claim **1**, wherein the selected IQS module is configured to:

apply a predicate to the subset of data.

3. The system of claim **2**, wherein the selected IQS module is configured to flag data of the subset passing the predicate.

4. The system of claim **3**, wherein the selected IQS module is configured to flag data of the subset failing the predicate.

5. The system of claim **1**, wherein the selected IQS module is configured to annotate a field of the data indicating the quality status.

6. The system of claim **1**, wherein the selected IQS module includes:

a selector module configured to select the subset of the data stream; and

a predicate module configured to apply a predicate to the selected subset of data to determine whether the selected subset of data meets the quality expectation of the analytic module.

7. The system of claim **6**, wherein the selector module is configured to select the subset of data based on a predetermined time period.

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